

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets

(11)



EP 0 866 139 B1

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(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
03.07.2002 Bulletin 2002/27

(51) Int Cl.⁷: **C21C 5/52, C21C 5/46,**
F27B 3/08

(21) Application number: **98104713.7**

(22) Date of filing: **16.03.1998**

(54) Method using a burner/lance for injecting gas into molten metal

Verfahren mit Brenner bzw. Lanze zum Einblasen von Gas in eine Metallschmelze

Procédé utilisant une lance ou un brûleur pour injecter du gaz dans un bain de métal

(84) Designated Contracting States:
BE DE ES FR IT NL

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(43) Date of publication of application:
23.09.1998 Bulletin 1998/39

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Description**Technical Field**

[0001] This invention relates generally to injecting gas such as oxygen into a furnace containing a pool of molten metal and is particularly advantageous for use in an electric arc furnace.

Background Art

[0002] In the processing of molten metal in a furnace it is often desired to provide gas such as oxygen into the molten metal. A recent significant advancement for molten metal processing in an electric arc furnace is the post combustion method disclosed and claimed in U.S. Patent No. 5,572,544 - Mathur et al., wherein main oxygen is provided into the molten metal from above the surface of the molten metal pool, and post combustion oxygen is provided into the furnace above but close to the surface of molten metal pool. In such a system, because the main oxygen must penetrate into the molten metal pool, it must be injected into the furnace very close to the molten metal surface using one or more water cooled lances or injected into the molten metal at a point below the surface of the molten metal pool using one or more pipes. However, this expediency is still not satisfactory because the proximity of the tip of the gas injection device to the liquid surface causes excessive but unavoidable wear to the water cooled lance type oxygen injector. Pipes must be continually advanced to compensate for melting and oxidation of the end immersed in the molten steel bath which not only requires pipe manipulating equipment but also is expensive due to continual loss of pipe. Moreover, since the surface of the molten metal is not stationary, the oxygen injector must be continually moved to ensure that the oxygen injection is done at the proper location and with the proper nozzle to molten metal pool surface distance.

[0003] US-A-4 622 007 relates to a blowing and heating device, e.g. for use in a scrap melting furnace, in which the conduits for injecting fuel are angled with respect to the main oxygen conduit. The main oxygen can be injected as a supersonic jet of excess oxygen to penetrate into the material being heated through a flame surrounding the supersonic oxygen jet. The secondary oxygen injected through an oxygen conduit is injected with subsonic velocity, with these oxygen jets serving to separate the central jet of main oxygen from the combustion products formed inside the combustion chamber by the combustion of fuel with air in oxygen.

[0004] WO-A-97/09566 relates to a blowing and heating device in a scrap melting furnace comprising a bath of molten metal wherein the device is located above the bath. The device comprises a conduit for injecting a substantially cylindric or weakly conical main oxygen jet into which fuel is injected via conduits which are angled with respect to the main oxygen jet. Air or an inert gas is in-

jected into the main oxygen jet via an annular gap.

[0005] WO-A-96/06954 relates to a blowing and heating device in an electric arc furnace. The device comprises a conduit for injecting main oxygen, a conduit for injecting fuel and conduits for injecting secondary oxygen. The oxygen conduit and the fuel conduit are angled with respect to the main oxygen conduit.

[0006] It is an object of this invention to provide a system for providing gas such as oxygen into a furnace containing a pool of molten metal wherein the gas passes into the molten metal pool, but excessive wear to the gas injection system is avoided.

[0007] There are times when it is desired to provide heat into a molten metal furnace, for example to melt scrap, in addition to providing gas into the molten metal pool. Accordingly, it is another object of this invention to provide a system for providing gas into a furnace so that the gas may be passed effectively into molten metal within the furnace while also providing heat into the furnace.

[0008] In the operation of an electric arc furnace it is desirable to generate a foamy slag layer above the molten metal pool. Accordingly it is a further object of this invention to provide a system for providing gas into an electric arc furnace so that the gas may be passed effectively into molten metal within the furnace while also generating a foamy slag above the molten metal.

[0009] In the operation of an electric arc furnace it is desirable to reduce the amount of fume which is generated. Accordingly, it is a further object of this invention to provide a system for providing gas into an electric arc furnace which minimizes the creation of splash and further provides a reducing atmosphere in the vicinity of the splash that does form to reduce the amount of fume formation.

[0010] In the operation of an electric arc furnace it is desirable to inject reagents such as carbon, lime, alloys, etc. in powder form into the bath. Accordingly, it is a further object of this invention to provide a system for providing gas into an electric arc furnace so that the gas may be passed effectively into molten metal within the furnace while also introducing powdered reagents into the molten metal.

Summary Of The Invention

[0011] The above and other objects, which will become apparent to those skilled in the art upon a reading of this disclosure, are attained by the present invention which is:

A method for providing gas into a furnace according to claim 1.

[0012] As used herein the term "oxygen" means a fluid having an oxygen concentration which exceeds that of air, preferably having an oxygen concentration of at least 30 mole percent, most preferably at least 80 mole percent. Oxygen may be commercially pure oxygen having an oxygen concentration of 99.5 mole percent or

more.

[0013] As used herein the term "flame envelope" means a combusting stream substantially coaxial with the main gas stream and annular thereto.

[0014] As used herein the term "slag" means a molten or solid layer of oxides generally comprising one or more of calcium oxide, silicon dioxide, magnesium oxide, aluminum dioxide and iron oxide.

[0015] As used herein the term "foamy slag" means a slag which also contains a high volume fraction of gas bubbles such as carbon monoxide which greatly reduces the density of the slag layer and imparts a foam like appearance and behavior to the slag layer.

Brief Description Of The Drawings

[0016] Figure 1 is an elevation view partly in cross section of an embodiment of the lance/burner of this invention in operation in an electric arc furnace.

[0017] Figures 2 and 3 are detailed views of one embodiment, Figure 2 being a cross sectional view and Figure 3 being a head-on view, of the injection end of the lance/burner useful in the practice of this invention.

[0018] Figure 4 is a representation of a preferred embodiment of the gas streams emitted from the lance/burner and of the flame envelope formed around the main gas stream in the practice of this invention.

[0019] The numerals in the Figures are the same for the common elements.

Detailed Description

[0020] In general, the invention comprises the creation and use of a jet of high velocity main gas such as oxygen which is maintained coherent by a flame envelope around the high velocity jet. The coherency of the jet enables the injection point of the jet into the furnace to be placed a significant distance above the surface of the molten metal pool while still enabling the jet to penetrate the surface of the molten metal pool so that the high velocity main gas can pass into the molten metal pool. The flame envelope is formed by combusting fluid, preferably injected into the furnace in two fluid streams which are each annularly coaxial with the high velocity gas stream. One of the fluid streams is a fuel stream and the other is a secondary oxygen stream. The slower moving flame envelope resulting from the combustion of the two annular streams forms a fluid shield or barrier around the high velocity gas stream greatly reducing gases from outside the high velocity gas stream being entrained into the high velocity gas stream. Normally, as a high velocity fluid stream passes through air or some other atmosphere, gases are entrained into the high velocity stream causing it to expand in a characteristic cone pattern. By action of the flame envelope barrier, this entrainment is greatly reduced for a significant distance from the point of injection into the furnace, and the high velocity gas jet substantially retains its original di-

ameter through this distance, i.e. is coherent through this distance. This coherency enables the jet to retain its ability to penetrate the molten metal bath and consequently the jet injection point can be spaced from the molten metal surface while still achieving adequate molten metal penetration. Moreover, if desired, the jet may contain powder or other additives which may be injected into the molten metal with the main gas.

[0021] A particularly advantageous application of this invention is its use in an electric arc furnace. In such practice the main gas jet comprises oxygen which reacts with carbon in the molten metal to form carbon monoxide which bubbles out of the molten metal. Post combustion oxygen reacts with this carbon monoxide above the surface of the molten metal pool providing additional heat into the furnace improving energy efficiency and productivity and reducing the level of deleterious carbon monoxide which is emitted into the atmosphere from the furnace.

[0022] The invention will be described in greater detail with reference to the drawings and also with reference to the electric arc furnace application for the invention.

[0023] Referring now to Figures 2 and 3, there is illustrated lance 1 having a central conduit 2, a first annular passageway 3 and a second annular passageway 4, each of the annular passageways being coaxial with central conduit 2. Central conduit 2 terminates at injection end 5 of lance 1 to form main orifice 6. The first and second annular passageways also terminate at the injection end, preferably, as illustrated in the Figures, in substantially the same plane as main orifice 6. The first and second annular passageways may each form annular orifices around main orifice 6. Preferably, as illustrated in Figure 3, first annular passageway 3 terminates at injection end 5 in a set of first injection holes 7 arranged in a circle around main orifice 6, and second annular passageway 4 terminates at injection end 5 in a set of second injection holes 8 arranged in a circle around main orifice 6 and first injection holes 7. Each of central conduit 2 and second annular passageway 4 communicate with a source of oxygen (not shown). The oxygen used in central conduit 2 and second annular passageway 4 may be the same oxygen fluid, or a different oxygen fluid may be used in second annular passageway 4 from that used in central conduit 2. First annular passageway 3 communicates with a source of fuel (not shown). The fuel may be any fuel, preferably is a gaseous fuel and most preferably is natural gas or hydrogen. In an alternative embodiment the fuel may be passed through the lance in the outermost annular passageway and the secondary oxygen may be passed through the lance in the inner annular passageway. In another alternative embodiment the fuel and secondary oxidant may be passed through the lance as a mixture through one annular passageway.

[0024] Referring to Figure 1 there is shown electric arc furnace 20 having sidewall 21 and bottom wall 22 and containing a bath comprising a pool of molten metal 23.

Generally the metal will comprise iron or steel. In Figure 1 there is also illustrated a slag layer 24, which may be molten or solid, above the pool of molten metal and a layer of scrap metal 25 above slag layer 24. The slag layer generally comprises one or more of calcium oxide, silicon dioxide, magnesium oxide, aluminum dioxide and iron oxide. The scrap layer, if present, is melted by heat provided by electrodes 26 to form molten metal pool 23. The molten metal pool comprises, in addition to metal, oxidizeable matter such as carbon and/or hydrocarbons.

[0025] Lance/burner 1 is positioned so as to pass through sidewall 21 with its injection end 5 above and spaced from the top surface of the bath by a distance along the jet axis of at least 20d, and may be spaced from the bath by a distance along the jet axis of up to 100d or more, where d is the exit diameter of the nozzle through which the main gas is ejected out from the lance/burner. The jet axis is the imaginary line running through the center of the jet along its length. Typically this spacing along the jet axis is within the range of from 30d to 60d. Figure 1, for illustrative purposes, shows one lance used with the furnace. In commercial practice it may be preferable to use more than one lance. Preferably, three or four lances are used, and their locations are chosen to provide heat to the normally colder regions of the furnace, such as between the electrodes and near openings in the sidewall or roof of the furnace. Main oxygen is injected into furnace 20 through nozzle orifice 6 of lance 1 toward the bath comprising molten metal pool 23 at an initial jet axis velocity, generally at least 305 m/s (1000 feet per second (fps)) and preferably at least 457 m/s (1500 fps), to form a high velocity main oxygen stream 30 as illustrated in Figure 4. The jet axis velocity is the velocity of the gas stream at its jet axis. The main oxygen will contact the bath at a velocity of at least 50 percent, preferably at least 75 percent of the initial jet axis velocity of the main oxygen stream. The main oxygen has a supersonic velocity upon ejection from the lance and also has a supersonic velocity when it contacts the bath.

[0026] Simultaneously with the injection of main oxygen, fuel is injected into furnace 20 through first injection holes 7 and secondary oxygen is injected into furnace 20 through second injection holes 8 to form a fuel stream and a secondary oxygen stream, each of these streams being concentric to and coaxial with stream 30. Secondary oxygen combusts with fuel to form flame envelope 33 which has a velocity which is less than that of main oxygen stream 30 and generally is within the range of from 15.2 to 152 m/s (50 to 500 fps). The flame envelope forms at or very close, e.g. within 25.4 mm (one inch), to the lance tip and extends substantially, i.e. at least 75 percent of, the entire length of the main gas stream within the furnace to the bath. Preferably the flame envelope extends the entire length of the main gas stream within the furnace to the bath.

[0027] Flame envelope 33 forms a barrier or shield

around oxygen stream 30 thereby greatly reducing the amount of gas outside of stream 30 from being entrained into stream 30. Thus stream 30 does not significantly expand from the point where it is injected into the furnace through lance 1 to the point where it impacts the bath comprising molten metal pool 23. Generally the diameter of stream 30 when it impacts the bath comprising molten metal pool 23 will be essentially the same as that when it is injected into furnace 20 through lance 1. Because stream 30 remains substantially coherent as it passes from the lance injection end to the surface of the bath, the injection end of the lance may be a large distance from the molten metal while still enabling the high velocity oxygen stream 30 to impact the molten metal pool surface with enough force so that the high velocity oxygen stream penetrates the bath surface and passes into the molten metal pool.

[0028] Within molten metal pool 23, the main oxygen in high velocity stream 30 reacts with oxidizeable matter within the molten metal pool. For example, the main oxygen may react with carbon in the molten metal pool to generate carbon monoxide in an exothermic reaction which provides additional heat to the furnace and stirs the molten metal to improve heat transfer. Gas generated by the reaction of main oxygen with oxidizeable matter within the molten metal pool bubbles up out of the molten metal pool. In many cases such gas or gases are in the form of incompletely combusted species, such as the aforesaid carbon monoxide. Such incompletely combusted species are environmentally deleterious and also represent an energy loss if allowed to pass unreacted out of the furnace. Post combustion oxygen provided into the furnace above the molten metal reacts with these incompletely combusted species as was previously described.

[0029] In one embodiment of this invention in the lance mode, the amount of fuel and secondary oxidant used is not significantly greater than that required to form the flame envelope. However, in some situations, it may be desirable to provide a large amount of heat into the furnace, such as, for example, to melt scrap in the furnace. In such situations a high flowrate of oxidant may be provided into the furnace and the fuel and oxidant, which may be secondary and/or main oxidant, is used to combust the fuel in order to generate heat for the furnace. That is, the lance used in the practice of this invention, may, if desired, also function as a burner i.e., in the lance/burner mode. In this way there is provided a very intense flame that can be used to penetrate and melt the scrap metal in order to provide an unobstructed passageway through which the oxygen jet may pass to reach the molten bath surface. Simultaneously, the flame can melt any scrap that may fall in front of the burner due to progression of scrap melting and cave-ins, thereby maintaining this passageway for bath lanceing. The high natural gas flow rate can also provide a blanket of fuel gas around the coherent jet as it penetrates the molten metal bath. When the coherent jet pen-

etrates the metal bath, a small localized cavity is formed and there is little deflection of the gas stream and little bath splashing. However, some spray may occur above the bath. The spray will be contained in a fuel gas blanket. This will prevent oxidation of metal droplets that leads to the formation of fume. Fume formation during lancing is thereby suppressed in two ways: (a) the amount of spray is greatly reduced by lancing with a coherent jet rather than a normal jet; and (b) the fuel gas blanket will prevent oxidation of metal droplets above the bath surface.

[0030] Moreover, in some situations it may be desirable to employ excess fuel and provide fuel into the molten bath along with the high velocity gas. One such situation would be to assist in generating a foamy slag in electric arc furnace practice. The foamy slag is very desirable in reducing energy losses from the electric arc and in reducing refractory wear at the furnace wall. In this situation, excess fuel such as natural gas is introduced into the slag layer where it undergoes decomposition and reaction to produce gases such as carbon monoxide, hydrogen and carbon dioxide which subsequently generates the desirable foamy slag. Moreover, in some situations it may be desirable to introduce reagents in powder form into the gas stream so that they may be effectively injected into the molten metal bath. Among such reagents one can name carbon, various compositions of lime, alloying additions, iron oxide, and dust produced by electric arc furnaces. Once the lance/burner of the invention is in place, it may also function solely as a burner during times when high velocity gas injection into the molten metal is not desired.

[0031] The following guidelines pertain to the design and operation of the invention as illustrated in Figures 2 and 3:

- 1) It is important to have some flow of oxygen in the outer ring of holes for all operating modes to stabilize the flames around the center jet. When operating in the lance and lance/burner modes, the flow of oxygen through the outer rings of holes should be at least 1% of the total oxygen flow and preferably in the range of about 5% to 10%.
- 2) When operating in the lance and lance/burner modes, the fuel gas flow rate through the inner ring of holes should be greater than that required to combust stoichiometrically with the oxygen in the outer ring of holes.
- 3) When operating in the lance and lance/burner modes, the velocity of the center jet should be greater than 152 m/s (500 fps) and preferably greater than 366 m/s (1200 fps).
- 4) When operating as a burner to preheat and melt cold metal scrap, the portion of the oxygen flow rate to the outer ring of holes should be between 25 and 75% of the total oxygen flow rate, preferably between 40 and 60% of the total oxygen flow rate and the total oxygen should be between 100 and 200%

of stoichiometric oxygen required to burn the fuel gas to completion.

5) When operating in the lance/burner mode to penetrate the partially melted scrap, the portion of the oxygen flow rate to the center jet should be greater than 50% and preferably between 75 to 99% of the total oxygen flow rate and the total oxygen should be greater than 100% stoichiometric oxygen required to burn the fuel gas to completion and preferably greater than 150%.

[0032] The following example of the invention is presented for illustrative purposes and is not intended to be limiting.

[0033] Using a system similar to that illustrated in Figure 1, oxygen was injected into a molten metal bath. The oxygen was ejected from the lance tip through a nozzle having an exit diameter of 2.05 cm (0.807 inch). The lance tip was positioned 71 cm (28 inches) above the surface of the bath and at a 40 degree angle to the horizontal so that the oxygen jet passed through a distance of 109 cm (43 inches) or 53 nozzle diameters from the lance tip to the bath surface. The main oxygen gas was enveloped in a flame envelope from the lance tip to the bath surface and had an initial jet axis velocity of 488 m/s (1600 fps) and maintained this jet axis velocity of 488 m/s (1600 fps) when it impacted the bath surface. About 85 percent of the oxygen ejected from the lance entered the molten metal pool and became available to react with constituents of the molten metal. About 10.4 m³ (367 standard cubic feet (SCF)) of oxygen per ton of molten metal was needed to burn out about 9.07 kg (20 pounds) of carbon per ton of the molten metal compared with about 15.8 m³ (558 SCF) of oxygen per ton of molten metal which was required for the same metallurgical operation but using conventional gas provision practice.

[0034] Now, by the use of this invention, one can more effectively provide gas into a molten metal furnace such as an electric arc furnace.

Claims

1. A method for injecting gas into, and penetrating the surface of, a pool of molten metal in a furnace from an injection point located in the furnace at a significant distance above the surface of the molten metal pool, wherein the molten metal pool has a layer of slag on its top surface, said method comprising;
 - (A) forming a coherent supersonic jet of gas in the furnace by
 - (1) injecting into the furnace above the molten metal pool, through a nozzle directed toward the surface of the pool, (a) a main gas stream whose initial jet axis velocity is supersonic and (b) a fuel and a secondary

- oxygen both of which are coaxial with and parallel to the supersonic main gas stream, and
- (2) surrounding the supersonic main gas stream with a flame envelope which is formed by combusting the fuel with the secondary oxygen and which extends substantially the entire length of the supersonic main gas stream in the furnace from the exit of the nozzle to the molten metal pool, wherein the nozzle has a main gas exit diameter d and wherein the distance from the exit of the nozzle to top surface of the molten metal pool along the jet axis is at least $20d$; and
- (B) penetrating the surface of the molten pool with the main gas stream whose jet axis velocity at that point is still supersonic.
2. The method of claim 1 wherein the main gas comprises oxygen.
3. The method of claim 2 wherein the pool of molten metal contains carbon and further comprising reacting main oxygen with carbon within the molten metal pool to form carbon monoxide, bubbling carbon monoxide out of the molten metal pool and injecting additional oxygen into the furnace above the molten metal pool to oxidize the carbon monoxide that bubbles out of the molten metal pool.
4. The method of claim 1 wherein the fuel and secondary oxygen are injected into the furnace in two streams, each of said two streams being concentric with the high velocity main gas stream.
5. The method of claim 1 wherein the main gas stream comprises an inert gas.
6. The method of claim 1 wherein some of the fuel does not combust and is passed into the slag layer wherein it reacts to form gas which serves to create a foamy slag layer.
7. The method of claim 1 wherein the main gas stream passed into the molten metal pool contains powder.
8. The method of claim 2 wherein the secondary oxygen is injected into the furnace at a flowrate which is within the range of from 25 to 75 percent of the total oxygen flowrate of the secondary oxygen and main gas oxygen injected into the furnace, and said total oxygen flowrate is within the range of 100 to 150 percent of that required to combust stoichiometrically with the fuel injected into the furnace.
9. The method of claim 2 wherein the main gas oxygen is injected into the furnace at a flowrate which is within the range of from 75 to 99 percent of the total oxygen flowrate of the secondary oxygen and main gas oxygen injected into the furnace, and said total oxygen flowrate is greater than 100 percent of that required to combust stoichiometrically with the fuel injected into the furnace.

10 Patentansprüche

1. Verfahren zum Injizieren von Gas in einen Sumpf aus schmelzflüssigem Metall in einem Ofen von einer Injektionsstelle aus, die in dem Ofen in wesentlichem Abstand oberhalb der Oberfläche des schmelzflüssigen Metallsumpfes angeordnet ist, wobei das Gas die Oberfläche des schmelzflüssigen Metallsumpfes durchdringt und der schmelzflüssige Metallsumpf eine Schlackenlage auf seiner Oberseite aufweist, wobei im Zuge des Verfahrens:

(A) ein kohärenter Überschallgasstrahl in dem Ofen gebildet wird, indem

(1) durch eine Düse, die zu der Oberfläche des Sumpfes hingerichtet ist, in den Ofen oberhalb des schmelzflüssigen Metallsumpfes (a) ein Hauptgasstrom injiziert wird, dessen anfängliche Strahlachsengeschwindigkeit im Überschallbereich liegt und (b) ein Brennstoff und Sekundärsauerstoff injiziert werden, wobei dies in beiden Fällen koaxial und parallel zu dem Überschallhauptgasstrom erfolgt, und

(2) der Überschallhauptgasstrom mit einer Flammenhülle umgeben wird, welche durch Verbrennen des Brennstoffs mit dem Sekundärsauerstoff gebildet wird und die sich im wesentlichen über den gesamte Länge des Überschallhauptgasstroms in dem Ofen von dem Ausgang der Düse bis zu dem schmelzflüssigen Metallsumpf erstreckt, wobei die Düse einen Hauptgasausgangsdurchmesser d aufweist und der Abstand von dem Ausgang der Düse bis zu der Oberseite des schmelzflüssigen Metallsumpfes entlang der Strahlachse mindestens $20d$ beträgt; und

(B) die Oberfläche des schmelzflüssigen Sumpfes mit dem Hauptgasstrom durchdrungen wird, wobei die Strahlachsengeschwindigkeit des Hauptgasstroms an diesem Punkt immer noch im Überschallbereich liegt.

2. Verfahren nach Anspruch 1, wobei das Hauptgas

Sauerstoff umfasst.

3. Verfahren nach Anspruch 2, wobei der Sumpf aus schmelzflüssigem Metall Kohlenstoff enthält und wobei ferner Hauptsauerstoff mit Kohlenstoff innerhalb des schmelzflüssigen Metallsumpfes zur Reaktion gebracht werden, um Kohlenmonoxid zu bilden, Kohlenmonoxid zum Herausperlen aus dem schmelzflüssigen Metallsumpf gebracht wird und zusätzlicher Sauerstoff in den Ofen oberhalb des schmelzflüssigen Metallsumpfes injiziert wird, um aus dem schmelzflüssigen Metallsumpf herausperlendes Kohlenmonoxid zu oxidieren. 5
 4. Verfahren nach Anspruch 1, wobei der Brennstoff und Sekundärsauerstoff in zwei Strömen in den Ofen injiziert werden, wobei jeder der beiden Ströme konzentrisch bezüglich des Hochgeschwindigkeits-Hauptgasstromes ist. 15
 5. Verfahren nach Anspruch 1, wobei der Hauptgasstrom ein inertes Gas umfasst. 20
 6. Verfahren nach Anspruch 1, wobei ein Teil des Brennstoffs nicht verbrennt und in die Schlackenlage eingeleitet wird, wo er reagiert, um Gas zu bilden, welches dazu dient, eine Schaumschlackenlage zu erzeugen. 25
 7. Verfahren nach Anspruch 1, wobei der in den schmelzflüssigen Metallsumpf eingeleitete Hauptgasstrom Pulver enthält. 30
 8. Verfahren nach Anspruch 2, wobei der Sekundärsauerstoff in den Ofen bei einer Durchflussrate injiziert wird, welche im Bereich von 25 bis 75 % der Gesamtsauerstoff-Durchflussrate des Sekundärsauerstoffs und des Hauptgas-Sauerstoffs liegt, die in den Ofen injiziert werden, und diese Gesamtsauerstoffdurchflussrate im Bereich von 100 bis 150 % der Durchflussrate liegt, die erforderlich ist, um mit dem in den Ofen injizierten Brennstoff stöchiometrisch zu verbrennen. 35
 9. Verfahren nach Anspruch 2, wobei der Hauptgasstrom in den Ofen bei einer Durchflussrate injiziert wird, die im Bereich von 75 bis 99 % der Gesamtsauerstoffdurchflussrate des Sekundärsauerstoffs und des Hauptgas-Sauerstoffs liegt, die in den Ofen injiziert werden, und die Gesamtsauerstoffdurchflussrate mehr als 100 % der Durchflussrate beträgt, die erforderlich ist, um stöchiometrisch mit dem in den Ofen injizierten Brennstoff zu verbrennen. 40
1. Procédé d'injection et de pénétration de gaz dans la surface d'une nappe de métal en fusion dans un haut fourneau à partir d'un point d'injection situé dans le haut fourneau à une distance significative au-dessus de la surface de la nappe de métal en fusion, dans lequel la nappe de métal en fusion a une couche de laitier à sa surface supérieure, ledit procédé comprenant les étapes consistant à :
- (A) former un jet supersonique cohérent de gaz dans le haut fourneau en
 - (1) injectant dans le haut fourneau, au-dessus de la nappe de métal en fusion, au moyen d'une buse dirigée vers la surface de la nappe, (a) un flux de gaz principal dont la vitesse axiale initiale du jet est supersonique et (b) un combustible et de l'oxygène secondaire, qui sont coaxiaux et parallèles au flux supersonique de gaz principal, et
 - (2) en entourant le flux supersonique de gaz principal du panache d'une flamme qui est formée par mise en combustion du combustible avec l'oxygène secondaire et qui s'étend sensiblement sur toute la longueur du flux supersonique de gaz principal dans le haut fourneau à partir de la sortie de la buse jusqu'à la nappe de métal en fusion, la buse ayant un diamètre d de sortie de gaz principal, et la distance entre la sortie de la buse et la surface supérieure de la nappe de métal en fusion le long de l'axe du jet étant d'au moins $20d$; et
 - (B) pénétrer la surface de la nappe de métal en fusion avec le flux de gaz principal dont la vitesse axiale du jet en ce point est encore supersonique.
2. Procédé selon la revendication 1, dans lequel le gaz principal comprend de l'oxygène. 45
 3. Procédé selon la revendication 2, dans lequel la nappe de métal en fusion contient du carbone, et comprenant, en outre, la mise en réaction de l'oxygène principal avec le carbone à l'intérieur de la nappe de métal en fusion pour former du monoxyde de carbone, le barbotage du monoxyde de carbone dans la nappe de métal en fusion et l'injection d'oxygène supplémentaire dans le haut fourneau, au-dessus de la nappe de métal en fusion, pour oxyder le monoxyde de carbone qui barbote dans la nappe de métal en fusion. 50
 4. Procédé selon la revendication 1, dans lequel le 55

combustible et l'oxygène secondaire sont injectés dans le haut fourneau sous la forme de deux flux, chacun desdits deux flux étant concentrique avec le flux de gaz principal à grande vitesse.

5

5. Procédé selon la revendication 1, dans lequel le flux de gaz principal comprend un gaz inerte.
6. Procédé selon la revendication 1, dans lequel une partie du combustible ne brûle pas et passe dans la couche de laitier dans laquelle il réagit pour former un gaz qui sert à créer une couche écumante de laitier.
7. Procédé selon la revendication 1, dans lequel le flux de gaz principal qui passe dans la nappe de métal en fusion contient une poudre.
8. Procédé selon la revendication 2, dans lequel l'oxygène secondaire est injecté dans le haut fourneau à un débit qui est compris entre 25 et 75 % du débit d'oxygène total formé de l'oxygène secondaire et de l'oxygène du gaz principal injectés dans le haut fourneau, et ledit débit d'oxygène total est compris entre 100 et 150 % de celui requis pour brûler de façon stoechiométrique avec le combustible injecté dans le haut fourneau.
9. Procédé selon la revendication 2, dans lequel l'oxygène du gaz principal est injecté dans le haut fourneau à un débit qui est compris entre 75 et 99 % du débit d'oxygène total formé de l'oxygène secondaire et de l'oxygène du gaz principal injectés dans le haut fourneau, et ledit débit d'oxygène total est supérieur à 100 % de celui requis pour brûler de façon stoechiométrique avec le combustible injecté dans le haut fourneau.

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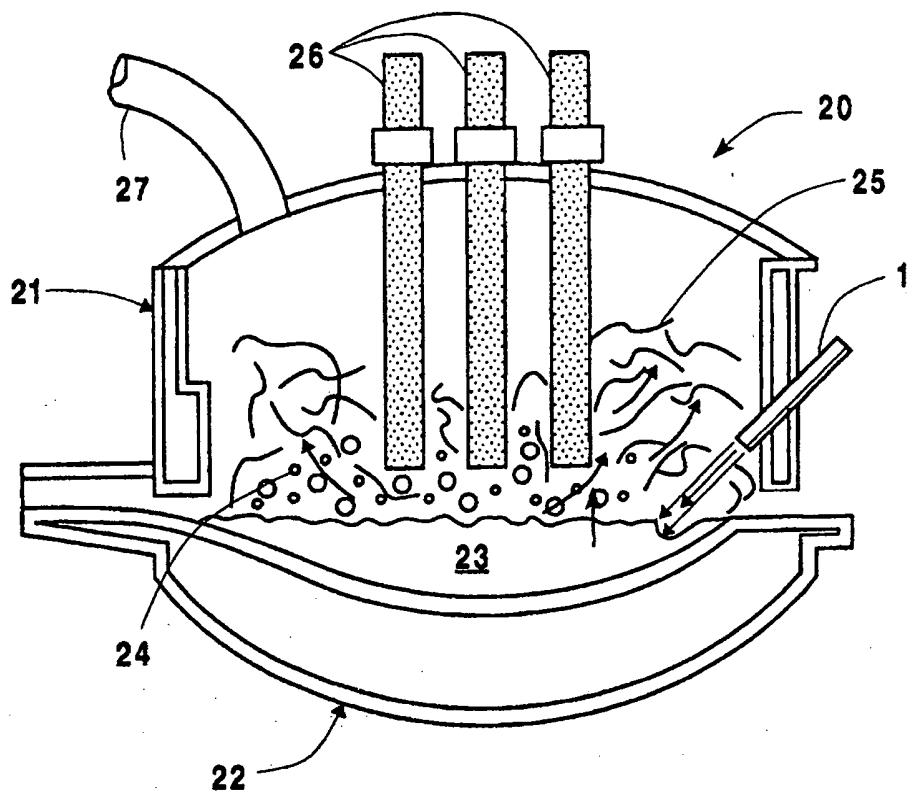
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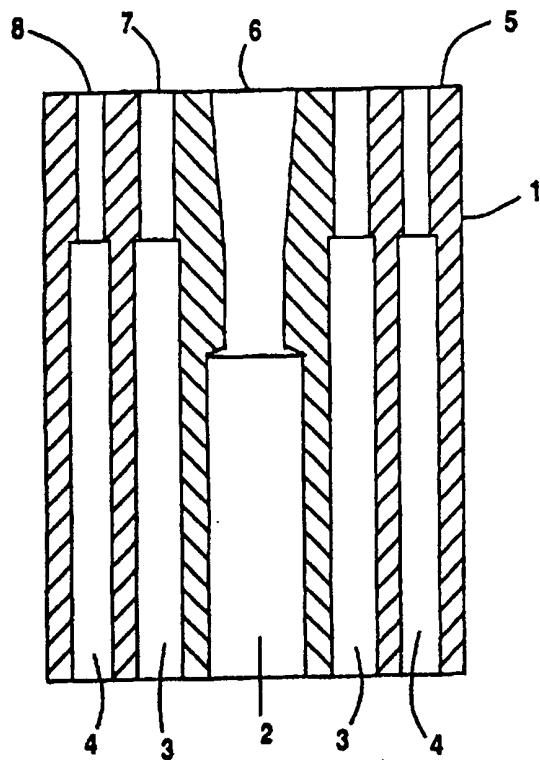
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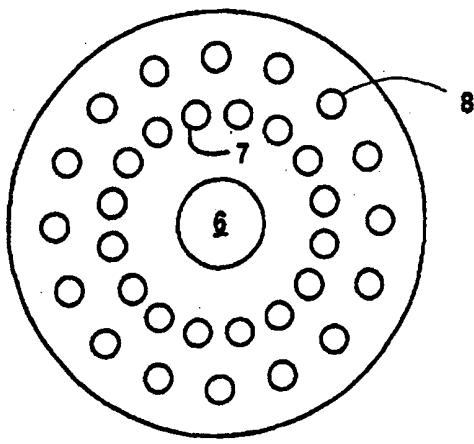
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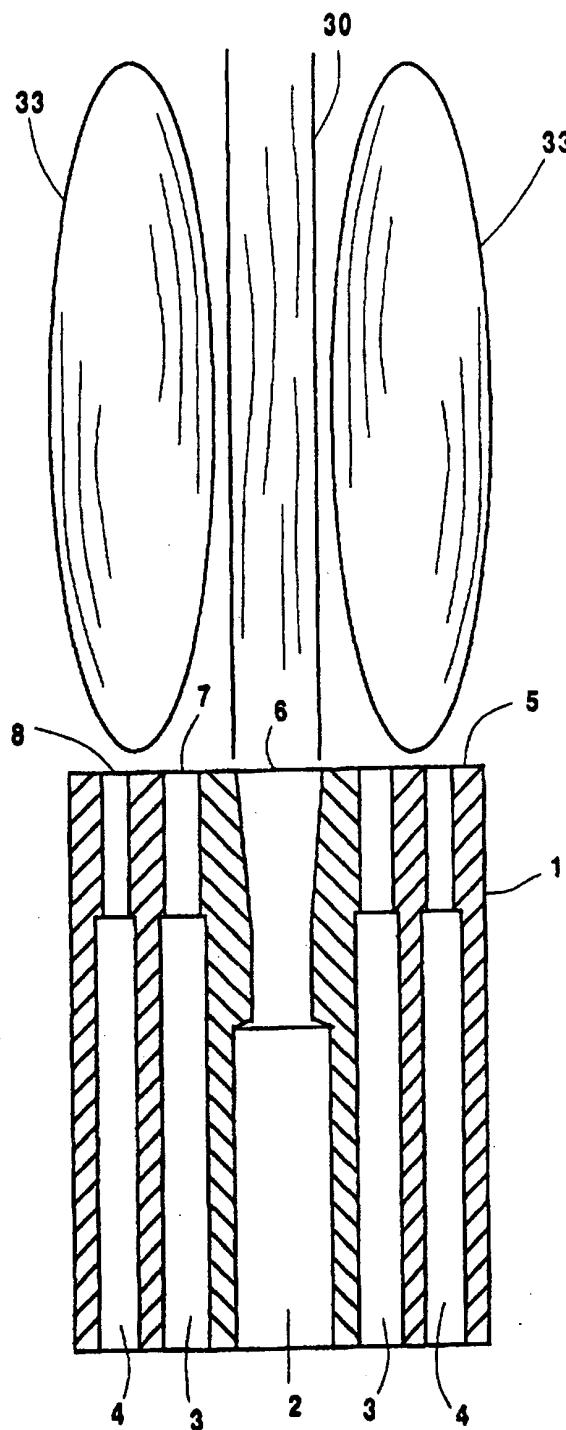
F i g. 1



F i g. 2



F i g. 3



F i g. 4

Lance/burner for molten metal furnace**Patent number:** EP0866139**Publication date:** 1998-09-23**Inventor:**
MATHUR PRAVIN CHANDRA (US);
SELINE RONALD JOSEPH (US);
ANDERSON JOHN ERLING (US)**Applicant:** PRAXAIR TECHNOLOGY INC (US)**Classification:****- international:** C21C5/52; C21C5/46; F27B3/08**- european:** C21C5/52B2; F27B3/22A**Application number:** EP19980104713 19980316**Priority number(s):** US19970819812 19970318**Also published as:**

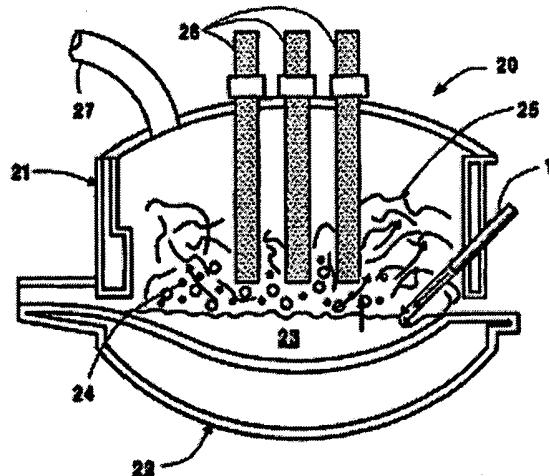
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Abstract of EP0866139

A method for effectively providing main gas into a pool of molten metal, which is particularly useful for use in an electric arc furnace. The method employs combustion of secondary oxygen with fuel to form a flame envelope around a main gas stream which protects the main gas from entrainment of ambient gases as it passes through the headspace of the furnace. This enables the gas to retain to a substantial degree its original force upon injection into the headspace and thus may be injected into the furnace at a safe distance from the molten metal surface while still achieving substantially complete penetration into the molten metal.

**Fig. 1**

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